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ARTICLE

Nonmetric cranial variation in human skeletal remains from Armenia

A.Yu. Khudaverdyan

Institute of Archaeology and Ethnography, National Academy of Science, Yerevan, Republic of Armenia

ABSTRACT Nonmetric traits are frequently analyzed in the field of anthropology to measure genetic relatedness, or biodistance, within or between populations. These studies are performed under the assumption that nonmetric traits are genetically inherited. Historically, interpretations of both biological and cultural change within the Armenian Highland, have cited large-scale population movements. Biological estimates of this change have traditionally relied upon biodistance estimates, using odontologic, craniofacial measures of both deformed and nondeformed skulls. In order to evaluate whether large-scale prehistoric and historic migrations occurred in the Armenian Highland, we examine biodistance results from nonmetric cranial traits for 19 samples that represent all time periods on Armenian Highland. None of the distances between each pair of samples examined by this study were significant. These results suggest biological continuity on the Armenia populations. Biodistance results also suggest endogamy within inland populations. The broader implications of these results are discussed.
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In the last 80 years (from Berry and Berry 1967; Movsesyan et al. 1975; Kozintsev 1988, to the recent papers by Prowse and Lovell 1996; Christensen 1997; Ishida and Dodo 1997; Sutter and Mertz 2004), a voluminous literature has been dedicated to the assessment of the biological significance and importance of nonmetric traits of the skull. Non-metric, discontinuous, or discrete, traits are anomalies in the normal anatomy of the skeleton. They are not measurable and are simply recorded on a present or absent basis. They are not generally considered to be pathological in origin, although in the case of some sutural variations, such as the presence of wormian bones, it has been thought possible that cultural practices may play some part in their appearance. The traits most commonly noted in most archaeological bone reports are those which are found on the skull. This is probably because more time and effort has been devoted to their study in the past, and consequently more documentation is available on them. The importance that both the environment (Piontek 1979, 1988; Hauser and Bergman 1984; Bergman and Hauser 1985; Bergman 1993; Rubini et al. 1997) and heredity have in their expression has been evaluated. It is assumed that the phenotype (observable characteristics) of an individual will provide direct information about his or her genotype (genetic constitution). With regard to the important contributions regarding heredity (Torgersen 1951a, 1951b; Berry 1975; Reinhard and Rösing 1985; Rubini 1997), we would particularly underline the report by Sjövold (1984). Nonmetric traits of the skeleton are therefore often used to assess genetic relatedness within (Cheverud and Buikstra 1981; Kohn 1991) and between past populations (Matsumura 2007; Saunders and Rainey 2008). Understanding these relationships in past populations (especially those without written histories) can provide information about migration patterns, residence patterns, population structures, and human origins and evolution (Lane and Sublett 1972; Mclellan and Finnegan 1990; Hanihara et al. 2003; Hlusko 2004; Turan-Ozdemir and Sendemir 2006).

The term “biodistance” is commonly used to describe genetic relatedness. Saunders and Rainey (2008) describe biodistance as a measure of the amount of divergence; less divergence is equal to a closer genetic relationship (Saunders and Rainey 2008; Sherwood et al. 2008). Christensen (1998) used biodistance analyses to trace the spread of the Zapotecan family of language throughout Oaxaca, Mexico. By analyzing both nonmetric traits and linguistic data, he determined that people migrating from a central area were able to establish themselves in other areas of Oaxaca. These groups become distinct from the parent population both in genetics and in language dialect. Alt et al. (1997) studied the nonmetric traits of the individuals in a triple burial in Dolce Vestonice. The data collected by this research team led them to conclude that the three were part of the same family. There are also various researchers who discuss the numerous factors that confound the heritability of nonmetric traits (Williams et al. 2005). Some factors that have been found to have a noticeable effect on the expression of these traits are geography, habi-

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*Corresponding author. E-mail: ankhudaverdyan@gmail.com; akhudaverdyan@mail.ru

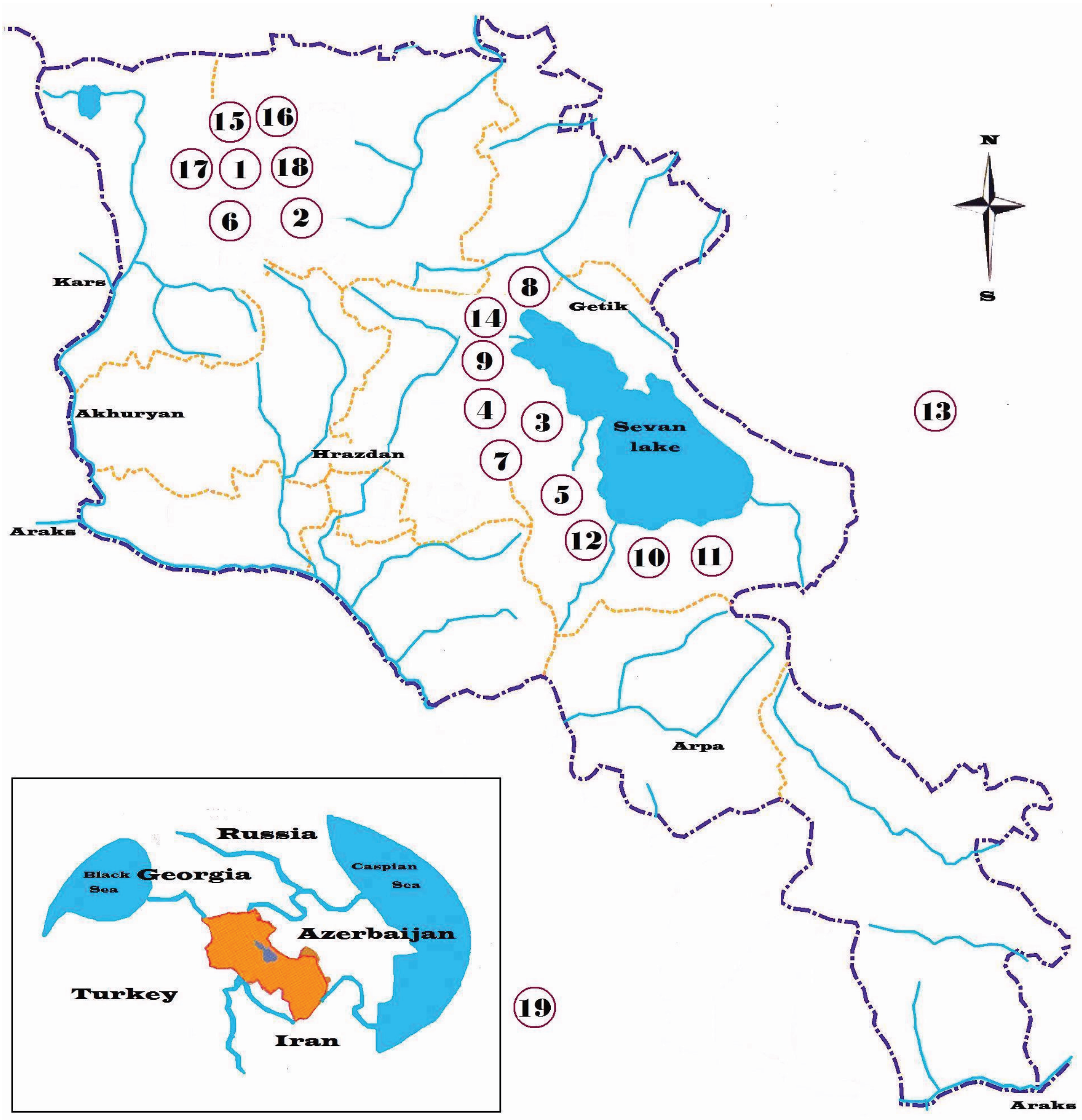

Figure 1. Map. Origins of 19 Armenian Highland samples used in the present study: 1. Landjik, 2. Black Fortress, 3. Nerkin Getashen I, 4. Nerkin Getashen II, 5. Nerkin Getashen III, 6. Artik, 7. Karmir, 8. Sarukhan, 9. Arcvakar, 10. Karashamb, 11. Akunk, 12. Lchashen, 13. Shushi, 14. Karchakhpyur, 15. Shirakavan, 16. Beniamin, 17. Vardbakh, 18. Black Fortress I, 19. Bingel Dag.

tat, sexual dimorphism (differences in physical appearance between individuals of different sexes in the same species), age, nutrition, disease, size, and intertrait correlations (Berry 1975; Cheverud et al. 1979).

The main purpose of this research project is to gain some insight into the expression of nonmetric traits on the human skulls from Armenian Highland (from Bronze Age to the beginning of 20 centuries). That study, on the heritability of some discontinuous traits based on a skeletal collection of individuals from various areas Armenian Highland with known family relationships, has provided a new stimulus in the scientific debate.

The Armenian Highland (also known as the Armenian Upland, Armenian Plateau, or simply as Armenia) is the central and highest of three land-locked plateaus that together form the northern sector of the Middle East (Hewsen 1997). The present Armenian Republic (Fig. 1) is located in the South Caucasus on the eastern end of the Armenian Plateau. The Armenian Highland were in early history a crossroads linking the worlds of East and West (Martirosyan 1964). Recent genetic studies confirmed that this avenue served not only a for commerce and cultural diffusion, but also for the exchange of genes (Balaresque et al. 2010). From 4 millennium BC to 1 millennium BC, tools and trinkets of copper, bronze and iron were commonly produced in this region and traded in neighboring lands where those metals were less abundant (Krupnov 1966; Trifonov 1991; Nechitailo 1991; Pystovalov 2002, etc.).

The invented in the Near East of wheeled vehicles and “kibetka-houses” on wheels allowed cattlemen-farmers to move and survive with ease on the open steppes. Their movement across Eurasia in early times was not a military invasion, but a slow expansion caused by a decline in the child mortality rate and a resultant increase in population growth. The wide expanse of the Eurasian steppes, offering favorable conditions for human life and the spread of information and technology, promoted a process of wide cultural integration in the Bronze Age throughout this area.

The craniological data allowed identification of alien Mediterranean characteristics influencing various ethnic Eurasian groups and revealed evidence of a migratory stream from the Armenian Highland and the Caucasus (Khudaverdyan 2011a). The Armenian Highland samples (Kura-Araxes culture) and the Catacomb culture samples from Kalmykia, Ukraine, Dnieper exhibit very close affinities to one another. If we follow a hypothesis put forward and developed by Gamkrelidze and Ivanov (1984) considering the ancestral home of Indo-European areas of the Armenian Highland and adjoining territories, whence other tribes get into the Northern Black coast both through the Caucasus and through Central Asia and the Volga region (carriers of a Catacomb culture ceremony), it is necessary to assign that movement to Aryan tribes, which were one of the first to get into Black Sea coast steppes through the Caucasus (or possibly by sea?). Khlopin (1983) connect the Catacomb culture with the Indo-Aryans. Fisenko (1966) suggest that the Catacomb people were Proto-Hittites. Kuzmina (1998) also is a supporter of the hypothesis Fisenko. Anthony (2007) supposed Catacomb people to be ancestors of Greeks, while Berzin and Grantovsky (1962), Klejn (1984) determine the Indo-Aryans originated from the Catacomb culture.

The craniological and odontological data exhibit close affinities the Armenian Highland samples (Kura-Araxes culture) and the samples from Moldova and Ukraine (Tripolye culture) (Khudaverdyan 2012b). Hence, it is possible to outline the cultural and ethnic communications in antiquity and the known role of the Armenian Highlands (Kura-Araxes culture) as the intermediary between ancient area of distribution of Tripolye cultures and the East countries (Passek 1949; Martiroyan and Mnacakanyan 1973; Lang 2005).

The Armenian Highland samples and the Albashevo, Fatianovo, Balanovo cultures and Timber Grave samples from Volga region exhibit very close affinities to one another (Khudaverdyan 2011b). The presence of the Mediterranean components was marked also by Trofimova (1949) in carriers of Fatianovo culture, Shevchenko (1984, 1986) and Khokhlov (2000) in carriers of Timber Grave cultures of the forest-steppe Volga region, and also by Yusupov (1989) in the Southern Urals Mountains.

The craniological researches indicate some morphological association of the Siberia samples (Eluninskaya and Andronovo cultures) with populations from the Caucasia (Solodovnikov 2008; Khudaverdyan 2011a). The different rates of genetic drift and external gene flow may have contributed to the morphological differentiation and diversification amongst the different Eurasian populations. The initial starting area (or one of the intermediate areas), as indicated by the anthropological data, would seem to be the Armenian Highland, and the Caucasus as a whole.

In the Ancient time (1st century BC – 3rd century AD) in the Armenian Highlands and Caucasus the interaction of different ethno-cultural units – Iranian-speaking nomadic (Scythians, Sarmatians, Sauromatians, Saka) (Herodotus IV; Strabo XI) and local. The advancement of the Scythians, Sarmatians and Saka in the territory of Armenian Highland and Transcaucasia was accompanied by not only an interaction of various cultural elements, but also a mixture. The detailed analysis of the anthropological materials from Armenia allows to explain not only the complicated anthropological compound of population but also to discover the reason of anthropological and ethnic non-homogeneity in populations of Ancient Age. Intragroup analysis revealed two groups within population (Khudaverdyan 2000). The dolichocephaly type in both cases is presented. The male skulls of the first group have been diagnosed as classical European group. The second is the same European type, but the horizontal profile of the face (group II) in them is a little weakened. The female skull group has the same analogical image as the males which allows to suppose the non-aboriginal elements in its structure. It is necessary to state that carriers of this complex remind one of Scythians from the territory of Moldova, Steppes of Black Sea Coast, Ukraine, Sarmatians from Volgo region and Saka from the territory of Turkmenistan (Khudaverdyan 2012a). The invasions of the various tribes all led, in stages, to a mixture of outsiders among the native Armenians and the dilution of their ranks on the plateau. The artificial modification of skulls (such as bregmatic, ring deformations of a head was known in the ancient population of the Beniamin, Shirakavan and Karmrakar, Vardbakh) and teeth in Ancient on the Armenia may be related to emerging social complexity and the need to differentiate among people, creating a niche for such a highly visual bodily markers (Khudaverdyan 2011c).

Materials and Methods

Eleven samples from 19 Armenian Highland samples were examined by this study (Fig. 1, Table 1). The Early Bronze

Table 1. Armenian Highland craniological samples.

	Sample name	Date	Researchers
1	Landjik	c. 4000-3000 BC	Khudaverdyan, 2009
2	Black Fortress	c. XIV-XII BC	Khudaverdyan, 2009
3	Nerkin Getashen I	c. XV BC	Movsesyan,1990
4	Artik	c. XV/XIV-XI BC	Movsesyan,1990; Movsesyan, Kochar, 2001
5	Total group: Landjik, Black Fortress, Nerkin Getashen I, Artik	I period	Khudaverdyan, 2009; Movsesyan,1990
6	Sarukhan	c. XI-IX/ VIII BC	Movsesyan,1990
7	Nerkin Getashen II	c. XIII-XII BC	Movsesyan,1990
8	Nerkin Getashen III	c. IX-VIII BC	Movsesyan,1990
9	Arcvakar	c. XI-IX/ VIII BC	Movsesyan,1990
10	Akunk	c. XI-IX/ VIII BC	Movsesyan,1990; Movsesyan, Kochar, 2001
11	Karashamb	c. XI-IX/ VIII BC	Movsesyan,1990
12	Karmir	c. XI-IX/ VIII BC	Movsesyan,1990
13	Lchashen	c. 3000 - 2000 BC	Movsesyan,1990
14	Shushi	c. 3000- 2000BC	Movsesyan,1990
15	Sarukhan, Nerkin Getashen II and III, Arcvakar, Akunk, Karashamb, Karmir, Lchashen, Shushi	II period	Movsesyan,1990
16	Shirak Plateau (total group): Landjik, Black Fortress, Artik	I period	Khudaverdyan, 2009; Movsesyan,1990
17	Sevan region (total group): Sarukhan, Nerkin Getashen II and III, Arcvakar, Akunk, Karashamb, Karmir, Lchashen	II period	Movsesyan,1990; Movsesyan, Kochar, 2001
18	Karchakhpyur-Shirakavan	c. 1 BC – AD 3	Movsesyan, Kochar, 2001
19	Beniamin	c. 1 BC – AD 3	Khudaverdyan, 2000
20	Vardbakh	c. 1 BC – AD 3	Khudaverdyan, 2005
21	Black Fortress I	c. 1 BC – AD 3	Khudaverdyan, 2005
22	Karchakhpyur-Shirakavan, Beniamin, Vardbakh, Black Fortress I	c. 1 BC – AD 3	Khudaverdyan, 2009; Movsesyan, Kochar, 2001
23	Bingel Dag	20 century	Bunak, 1927; Movsesyan, Kochar, 2001

period (4000-3000 BC) farmer and cattle-breeder Landjik represent the Kuro-Arexes population of the Shirak Plateau (Khudaverdyan 2009). The Late Bronze period is represented by remains from three Armenian Highland samples. The combination of remains from these four sites is justified for three reasons. First, the small sample sizes for samples (Landjik, Black Fortress, Nerkin Getashen I) were inadequate (from 10-15 individuals) for subsequent biodistance analysis (Movsesyan 1990; Khudaverdyan 2009). Second, the Landjik, Black Fortress, Artik samples they represent a cemetery from Shirak Plain. Indeed, the geographic distance among sites a little. Finally, analysis of all nonmetric cranial traits examined by this study revealed that no significant differences exist among remains from the four samples, so data from these samples were combined for subsequent statistical analyses. An adequate number of remains were available from Artik sample (Movsesyan 1990; Movsesyan, Kochar 2001), and were therefore analyzed as a single sample. Nine Late period (XI-IX/VIII BC) samples were analyzed in this investigation. The different site designations for Nerkin Getashen I, Nerkin Getashen II, and Nerkin Getashen III represent different time periods, rather than spatially discrete cemeteries (Movsesyan 1990; Movsesyan, Kochar 2001). Samples (Sarukhan, Nerkin Getashen II, Nerkin Getashen III, Arcvakar, Akunk, Karashamb, Karmir, Lchashen) included in the II period are located from the Sevan region (Movsesyan1990; Movsesyan, Kochar 2001). Nonmetric cranial trait data from Sarukhan, Nerkin Getashen II, Nerkin Getashen III, Arcvakar, Karashamb, Karmir, Shushi were combined to an inadequate number for subsequent biodistance analysis (Movsesyan 1990; Movsesyan, Kochar 2001). Remains from Akunk and Lchashen burials were treated as an independent sample because a sufficient number of crania from these cemeteries were available for study (Movsesyan 1990; Movsesyan, Kochar 2001). Late Intermediate period (1st century BC – 3rd century AD) samples examined by this study include remains from Karchakhpyur, Shirakavan, Beniamin, Vardbakh, Black Fortress I (Khudaverdyan 2000, 2005, 2009; Movsesyan, Kochar 2001). Bunak after the armenian genocide the 1915 year has collected a big collection (Museum of Anthropology, Moscow) of human skulls (*i.e.* the victims a genocide). The modern population is include remains these people (Bingel Dag: armenians from Musha) (Bunak 1927; Movsesyan, Kochar 2001).

For this study, 23 nonmetric (*i.e.*, epigenetic) cranial and mandibular traits are used to assess the biological affinities (Table 2) among the 19 prehistoric and historic Armenian Highland samples examined here (Table 1). All traits examined in this study were successfully used by other biodistance studies, and their scoring procedures and descriptions are well-known in the literature (Berry and Berry 1967; Movsesyan 1975, 1990; Kozintsev 1980, 1988). Cranial nonmetric traits have successfully been used to evaluate the evolutionary relations and biological affinities among numerous archaeo-

Table 2. A complete list of nonmetric traits analyzed and the methods used to score them.

Trait	Scoring Method
Sutura metopica	absent, complete
Foramen supraorbital	presence/absence
Foramen infraorbitale accessorium	two distinct foramina, more than two distinct foramina
Foramen parietale	present (on parietal), present (sutural). Absent
Os bregmaticum	presence/absence
Os epiptericum	presence/absence
Os apicis lambdae	presence/absence
Os asterii	presence/absence
Ossa suturae coronalis	presence/absence
Ossicula suturae squamosae	presence/absence
Ossa suturae sagittalis	presence/absence
Ossa suturae lambdoïdeae	presence/absence
Canalis condylaris intermedius	patent, not patent
Canalis hypoglossi bipartite	complete (within canal)
Foramen mastoideum absent	absent, 1, 2, more than 2
Foramen mastoideum exsutural	absent, 1, 2, more than 2
Foramen spinosum bipertitum	partial formation
Foramina alatine minoranus	absent, 1, 2, more than 2 (the lesser palatine foramina lie on both sides of the posterior border of the hard palate immediately posterior to the greater palatine foramen)
Foramina mentale accessorium	absent, 1, 2, more than 2
Os zygomaticum bipartitum	presence/absence
Tuberculum praecondylare	presence/absence (immediately anterior and medial to the occipital condyle)
Torus palatinus	presence/absence

logical samples (e.g., Ishida and Dodo 1997; Blom 1998). Nonmetric cranial traits have the advantage of being scoreable for highly fragmented skeletal materials. Although some studies reported that some nonmetric cranial traits are influenced by cranial deformation (Ossenberg 1970; Konigsberg et al. 1993), other studies indicated that most nonmetric cranial traits' expressions are largely free of influence from artificial cranial deformation (Griffin 1995; Khudaverdyan 2000).

Data are subjected to the component and cluster analysis. The clustering procedures produce branching tree diagrams to illustrate similarities/differences among cases in complex data matrices by forming clusters that minimize intracluster variation while maximizing intercluster variation. Inspection of the 23 nonmetric cranial traits, frequencies retained for biodistance analysis indicates that some of the traits, expressions demonstrate a geo-temporal trend.

In total, the comparative analysis included 15 craniological series from the territory of Eurasia (2 samples /Fatianovo and Balanovo cultures/ from Volga region (Chesnis 1986), 2 samples /Sapallitepe, Gonur Depe/ from Central Asia (Khodjaiov 1977; Nevchaloda and Kufterin 2008), 4 samples /Afanasevo, Andronovo, Karakolskaya and Tagarskaya cultures/ from Siberia (Kozintsev 1980), 4 samples /Chernyakhov culture/ from Ukraine (Chesnis and Konduktorova1982), 2 samples /Budeshti, Malaeshti/ from Dnestr region (Chesnis and Konduktorova 1982), 1 sample /Latgali/ from Latvia (Chesnis 1986)). Kozintseva and Kozintseva's statistical package (Museum of Anthropology and Ethnography of name of the Peter the Great, St. Petersburg) has been used.

Results and Discussion

The remaining 23 traits, their frequencies, and the number of individuals observed for each trait for the 9 Armenian Highland samples are provided in Table 3 (only Bingel Dag sample – in radians). More specifically, the presence sutura metopica, sagittal, squamosae ossicles, multiple infraorbital foramina, foramen spinosum, bridging of the mylohyoid groove, tuberculum praecondylare and palatine torus show a chronological trend between two samples (I and II periods: from Bronze to Iron Ages). For the multiple infraorbital foramina, and os zygomaticum, the Ancient sample (Beniamin-Vardbakh-Black Fortress I) generally have higher frequencies of expression for these traits. For the palatine torus, the Artik, Akunk, Lchashen, and Karchakhpyur-Shirakavan samples have the lowest frequencies of expression, while the Beniamin-Vardbakh-Black Fortress I and all samples Bronze Age (I period) are characterized by relatively higher levels of expression. Coronal ossicles show a slight temporal trend (*i.e.*, Ancient period) than Bronze period (I period) characterized by higher frequencies of expression.

The analysis 1. Brothwell (1959) who first used an array of ten non-metrical traits to the study of multivariate distances among populations. The number of traits was further

Table 3. Number of affected and observed crania, and their dichotomized trait frequencies by mortuary sample for 23 nonmetric cranial traits used in biodistance analysis*.

	Traits	Bronze	Age	Bronze	Iron Age	Artik		Akunk		Lchashen		An-cient	Age	An-cient	Age	Ancient	Age	Modern	Arme-nians
		I	pe-riod	II	period	I	pe-riod	II	pe-riod	II	pe-riod	Benia-min	et all	Shi-rak	avan	Total	group	Bingel	Dag
		A/	O	A/	O	A/	O	A/	O	A/	O	A/	O	A/	O	A/	O	R	
1	Sutura metopica	21.2/	54	12.3/	259	19.47/	36	4.35/	28	13.49/	126	17.8/	58	6.67/	30	12.3/	88	225	
2	Foramen sup-raorbital	54.5/	54	45.1/	222	36.11/	36	27.27/	22	44.00/	125	44.95/	82	40.7/	27	42.9/	108	38	
3	Foramen infra-orbitale acces.	19.8/	65	9.71/	245	11.11/	36	4.76/	21	8.80/	125	38.2/	50	5.0/	20	21.6/	70	97	
4	Os zygomaticum bip.	13.92/	67	11.3/	251	2.78/	36	1.19/	21	6.50/	123	39.6/	52	5.56/	18	22.6/	70	46	
5	Os bregmaticum	2.8/	60	1.9/	259	2.78/	36	1.08/	23	0.22/	125	1.93/	52	0.83/	30	1.38/	82	10	
6	Ossa suturae coronalis	15.99/	67	10.4/	229	2.78/	36	4.35/	23	3.22/	125	10.1/	113	3.45/	29	6.8/	142	25	
7	Os epiptericum	35.9/	67	23.4/	220	17.14/	35	4.76/	21	20.00/	120	20.2/	57	21.74/	23	21.0/	80	163	
8	Ossicula suturae squamosae	18.7/	66	6.2/	228	2.78/	36	4.35/	23	3.34/	120	18.5/	89	0.92/	27	9.8/	116	15	
9	Os asterii	18.9/	65	7.8/	239	8.33/	36	1.08/	23	6.50/	123	10.9/	46	3.44/	29	7.2/	75	132	
10	Foramen parietale	56.4/	58	53.97/	236	47.22/	36	34.78/	23	43.65/	126	54.5/	80	46.42/	29	50.5/	109	387	
11	Os apicis lambdae	15.6/	66	12.7/	234	2.78/	36	8.69/	23	4.84/	124	10.0/	50	10.71/	28	10.4/	78	62	
12	Ossa suturae sagittalis	19.1/	65	3.97/	250	0.69/	36	1.08/	23	0.81/	124	5.4/	92	0.83/	29	3.2/	101	-	
13	Ossa suturae lambdoïdeae	48.8/	68	40.6/	253	22.22/	36	47.82/	23	25.60/	125	58.7/	101	28.58/	28	43.7/	129	341	
14	Foramen masto-ideum absent	57.6/	65	42.98/	255	37.14/	36	21.40/	23	34.92/	126	65.8/	73	28.57/	28	47.2/	92	294	
15	Foramen masto-ideum exsutural	29.6/	64	23.7/	252	17.14/	35	30.43/	23	34.92/	126	33.6/	87	28.57/	28	31.1/	115	248	
16	Canalis condylaris intermed.	62.3/	60	61.4/	228	53.33/	30	44.44/	18	63.93/	122	61.5/	45	46.66/	15	54.1/	60	697	
17	Canalis hypoglossi bipartite	25.5/	60	27.6/	227	23.33/	30	33.33/	18	22.13/	122	37.5/	24	46.66/	15	42.1/	39	333	
18	Tuberculum praecondylare	21.1/	60	8.9/	250	3.33/	30	5.55/	18	5.73/	122	27.3/	22	6.67/	15	16.99/	37	85	
19	Foramen spino-sum bipertitum	30.5/	64	9.3/	227	11.42/	35	4.54/	22	8.06/	122	40.0/	25	25.92/	17	32.96/	42	62	
20	Torus palatinus	39.6/	62	22.7/	233	15.15/	33	16.67/	18	14.63/	124	40.9/	89	1.47/	17	21.2/	106	198	
21	Foramina palatina minoranus	52.9/	63	43.8/	230	40.24/	33	50.0/	14	38.84/	121	49.1/	60	52.94/	17	51.1/	77	-	
22	Sulcus mylo-hyoideus	18.4/	30	24.7/	116	-		-		19.35/	62	-		-		-		-	
23	Foramina mentale accessor.	21.6/	29	9.2/	56	-		-		-		22.0/	55			22.0/	55	-	

* O: number of crania actually observed; A: number of crania showing trait (affected); R – radians

Table 4. Elements of three initial components for 11 groups.

Trait	I	II	III
Sutura metopica (frontalis)	0.976	0.017	0.066
Foramen supraorbital	-0.711	0.642	0.227
Foramen infraorbitale accessorium	0.486	0.693	-0.500
Os zygomaticum bipartitum	0.014	0.932	-0.253
Ossa suturae coronalis	-0.233	0.882	0.280
Os epiptericum	0.823	0.326	0.399
Os asterii	0.882	0.427	0.064
Foramen parietale	0.938	-0.090	0.007
Canalis condylaris intermedius	0.975	-0.003	0.114
Canalis hypoglossi bipartite	0.897	-0.290	-0.106
Values	58.403	29.200	6.361

Table 5. Values of three initial components for 11 groups.

Sample name	I	II	III
Lchashen	-0.949	-1.043	0.215
Akunk	-2.446	-2.555	-0.494
Artik	-0.757	-1.387	-0.151
Shirak Plateau /I period/	-0.351	2.582	0.423
Sevan region /II period/	-0.362	0.755	0.996
Beniamin-Vardbakh-Black Fortress I	0.356	2.164	-1.720
Karchakhpyur-Shirakavan	-1.644	-1.591	0.316
Armenia (I period: Bronze Age)	0.209	1.558	0.840
Armenia (II period: Bronze and Early Iron Ages)	-0.401	0.549	0.497
Armenia (III period: Ancient Age)	-0.537	0.471	-0.929
Armenia (IV period: Modern Armenians)	6.882	-1.503	0.007

increased after Berry and Berry's paper (1967) has been published. Those traits were frequently employed not only to compare populations by the multivariate distances method, but also to study processes affecting genetic variation of the population structure and to determine kinship among individuals, etc. The purpose of analysis is to gain some insight into the expression of nonmetric traits on the human 11 samples from Bronze to the beginning of 20 centuries from Armenian Highland. Components for the first three factors are given in Table 4. As is to be expected, the first component accounts for the majority (58.5%) of the intergroup discrimination. Taking into account character of connection of attributes in this component, it is possible to tell that the large values till I coordinate axes correspond to groups with sutura metopica (0.976), canalis condylaris intermedius (0.975), foramen parietale (0.938), canalis hypoglossi bipartite (0.897), os asterii (0.882) and os epiptericum (0.823). The negative weight gives a foramen supraorbitale (-0.711). The group closest to the Bronze Age /I period/ are the Beniamin-Vardbakh-Black Fortress I. Interestingly, and the group from II period (Bronze and Early Iron Ages) is closer to the ancient sample (Table 5).

The second component (29.2%) are maximum for os zygomaticum bipartitum (0.932), ossa suturae coronalis (0.882), foramens infraorbitale accessorium (0.693) and supraorbitale (0.642). The third component accounts for the 6.4% of the intergroup. The negative weight gives a foramen infraorbitale accessorium (-0.500).

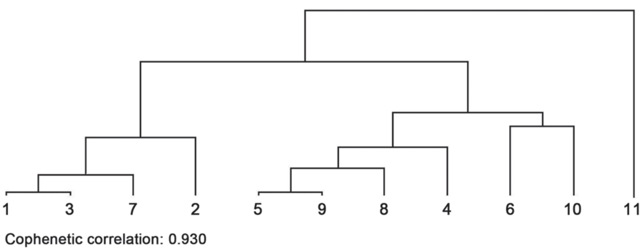

Figure 2. Cluster tree: 1. Lchashen, 2. Akunk, 3. Artik, 4. Shirak Plateau /I period/, 5. Sevan region /II period/, 6. Beniamin-Vardbakh- Black Fortress I, 7. Karchakhpyur-Shirakavan, 8. I period (total group: Bronze Age), 9. II period (total group: Bronze and Early Iron Ages), 10. III period (total group: Ancient Age), 11. IV period (Bingel Dag).

Next, we applied the cluster analysis (Fig. 2, Table 6). The Lchashen, Akunk and Akunk samples are relatively close to the Karchakhpyur-Shirakavan sample in this diagram. Importantly, Ancient sample (Karchakhpyur-Shirakavan) are closely related to the previous samples (Bronze and Iron Ages). The most isolate Bingel Dag sample in Figure 2. The prehistoric series, including the Shirak Plateau (I period), Sevan region (II period), the groups from I and II periods (Bronze and Early Iron Ages) are nearer the Ancient samples (total group and Beniamin-Vardbakh-Black Fortress I), as mentioned above.

Undertaken here is a analysis of more than 14 groups of the Bronze and Iron Ages from the territory of Eurasia. The anthropological cover of Eurasia, generated during exclusively difficult historical events (Abdushelishvili 1982, 2003; Khudaverdyan 2011a, 2011b). The advancement of the Mediterraneans in the territory of Eurasia was accompanied by not only an interaction of various cultural elements, but also a mixture – a distribution sometimes at considerable distances from their centre of formation. On the basis of the received information, cluster analysis will has shown the epigenetic condensations of groups from Eurasia and factors of relatives or, conversely, distinctions between them.

The analysis 2. Placement of the 14 samples determined by the values of factors I (35.2%) and II (28.3%) (Table 7). The positive weight (factor I) given for maximum foramens mastoideum (0.892) and parietale (0.799), ossa suturae lambdoïdeae (0.877), os apicis lambdae (0.788) and canalis condylaris intermedius (0. 794). Values of three initial components for 14 samples are provided in Table 8. Inspection of the 12 nonmetric cranial traits, frequencies retained for biodistance analysis indicates that some of the traits, expressions demonstrate a geographic or ethnic trend. More specifically, the populations from Volga regions and Siberia show a ethnic trend between samples (a positive field). The

Table 6. Matrix of distance, values for eleven Armenian Highland mortuary samples examined in this study.

Sample name	1	2	3	4	5	6	7	8	9	10	11
1.Lchashen											
2. Akunk	2.24										
3. Artik	0.54	2.08									
4. Shirak Plateau /I period/	3.68	5.62	4.03								
5. Sevan region /II period/	2.05	4.19	2.46	1.92							
6. Beniamin-Vardbakh, Black Fortress I	3.97	5.62	4.04	2.30	3.14						
7. Karchakhpyur-Shirakavan	0.89	1.49	1.02	4.37	2.76	4.72					
8. Armenia (I period: Bronze Age)	2.91	5.07	3.25	1.24	1.00	2.64	3.69				
9. Armenia (II period)	1.71	3.85	2.07	2.04	0.54	2.85	2.48	1.23			
10. Armenia (III period)/	1.94	3.60	2.03	2.51	1.95	2.07	2.65	2.21	1.43		
11. Armenia (IV period)/	7.85	9.40	7.64	8.32	7.65	7.68	8.53	7.39	7.58	7.73	-

Armenian Highland samples and the Mediterranean samples from Central Asia exhibit close affinities to one another (a negative field).

Factor II has its strongest value ossa suturae coronalis (0.896), sagittalis (847), sutura metopica (0.749), os asterii (0.708) and torus palatines (0.608). The III component accounts for the 17.99% of the intergroup discrimination. Component III has its strongest positive value an foramen supraorbitale (0.741) and negative weight an canalis hypoglossi bipartite (-0.850).

The diagonal matrix of distance is provided in Table 9. The dendrogram gives a visual idea of the relationship between the various groups (Fig. 3). Cluster analysis provides a different representation of the distance matrix, because it is an unrooted tree whose branches have different lengths. Long branch lengths may be interpreted as an indicator of a large degree of morphological separation, while short branch lengths are indicative of a small degree of morphological separation between samples. The Artik sample features a close affinity with those of the Lchashen and Akunk samples. Armenian samples from I and II periods (Bronze and Iron Ages), Shirak Plateau and Sevan region serve as a epigenetic link between Central Asia (Sapallitepe, Gonur Depe) samples that feature the closest affinities to one another. Within the dendrogram are samples from Armenia featuring the closest affinities to one another. These four prehistoric skeletal series of different periods from Siberia also are similar to other series in the same region. Within the dendrogram are samples from Volgo region featuring the closest affinities to one another (Fatianovo and Balanovo cultures). So, the cluster analysis of the 12 nonmetric cranial traits of samples in Bronze and Iron Ages from Eurasia, indicates that some of the traits, expressions demonstrate a ethnic trend.

Let's continue the analysis (3) of 11 series. Factors for the first three canonical variates are given in Table 10. Factor I (38.8%) has its strongest value canalis condylaris intermedius (0.863), foramen parietale (0.826), os asterii (0.659) and ossa suturae lambdoïdeae (0.658). High negative value correspond to the foramen supraorbitale (0.691).

The populations from Ukraine, Moldova (Chernyakhov culture) and Latvia (Latgali) show a close affinities to one another (a positive field). All the Armenia samples also exhibit close affinities to one another (a negative field). The sample

Table 7. Elements of three initial components for 14 groups.

Trait	I	II	III
Sutura metopica	-0.465	0.749	-0.210
Foramen supraorbitale	-0.297	0.444	0.741
Ossa suturae coronalis	-0.316	0.896	0.044
Os asterii	0.100	0.708	0.245
Foramen parietale	0.799	0.039	0.376
Os apicis lambda	0.788	0.202	0.069
Ossa suturae sagittalis	0.262	0.847	0.371
Ossa suturae lambdoïdeae	0.877	-0.081	0.148
Foramen mastoideum absent	0.892	-0.031	0.208
Canalis condylaris intermedius	0.794	0.023	-0.358
Canalis hypoglossi bipartite	0.097	0.429	-0.850
Torus palatines	0.524	0.608	-0.552
Values	35.194	28.205	17.989

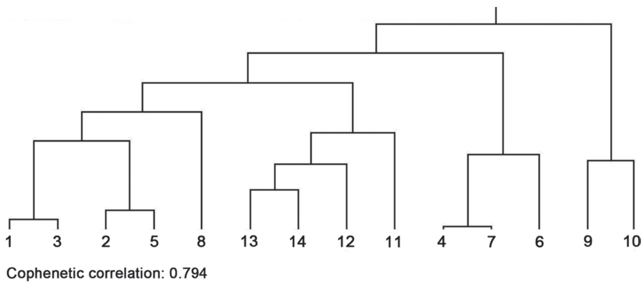

Figure 3. Cluster tree: 1. Armenia (I period: Bronze Age), 2. Armenia (II period: Bronze and Early Iron Ages), 3. Shirak Plateau (I period), 4. Artik, 5. Sevan region (II period), 6. Akunk, 7. Lchashen, 8. Central Asia (Sapallitepe-Gonur Depe), 9. Volga region (Fatianovo culture), 10. Volga region (Balanovo culture), 11. Siberia (Andronovo culture), 12. Siberia (Afanasevo culture), 13. Siberia (Karakolskaya culture), 14. Siberia (Tagarskaya culture).

Table 8. Values of three initial components for 14 groups.

Sample name	I	II	III
Armenia /I period: Bronze Age/	-0.118	3.235	0.401
Armenia /II period: Bronze and Early Iron Ages/	-0.710	1.032	-0.294
Shirak Plateau /I period/	-0.199	3.671	0.035
Artik	-2.788	-0.997	-1.242
Sevan region /II period/	-0.751	1.713	-0.058
Akunk	-1.982	-2.123	-2.252
Lchashen	-2.476	-1.170	-0.955
Central Asia /Sapallitepe, Gonur Depe/	-1.926	-0.071	1.900
Volga region /Fatianovo Culture/	3.723	-0.344	-2.469
Volga region /Balanovo Culture/	3.705	-0.196	-0.881
Siberia /Andronovo Culture/	1.669	-2.518	2.327
Siberia /Afanasevo Culture/	0.184	-1.536	1.612
Siberia /Karakolskaya Culture/	0.369	-0.547	1.068
Siberia /Tagarskaya Culture/	1.301	-0.151	0.809

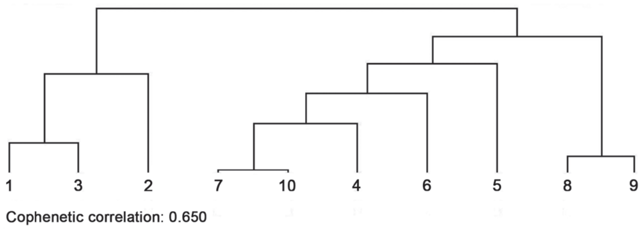

Figure. 4. Cluster tree: 1. Armenia (Beniamin-Vardbakh-Black Fortress I), 2. Armenia (Karchakhpyur-Shirakavan), 3. Armenia (total group: Ancient Age), 4. Ukraine (Dzuravka), 5. Ukraine (Chernykhov- Romashki-Derevynnoe-Teleshovka), 6. Ukraine (Gavrilovka-Voloshskoe), 7. Ukraine (Koblevo-Ranjevoe-Viktorovka, 8. Dnestr region (Budeshti), 9. Dnestr region (Malaeshti), 10. Latvia (Latgali).

from Budeshti (Chernyakhov culture) occupies a unique position among Moldova samples by exhibiting much closer affinities to the Armenia samples (Table 11).

The positive weight (factor II, 28.3%) given for maximum foramen infraorbitale accessorium (0.859) and ossa suturae lambdoïdeae (0.630). The third component accounts for the 14.7% of the intergroup. The positive weight gives a canalis hypoglossi bipartite (-0.916).

The diagonal matrix is provided in Table 12. The dendrogram gives a visual idea of the relationship between the various groups (Fig. 4). Interestingly, the total sample from Beniamin-Vardbakh-Black Fortress I is most similar to the Karchakhpyur-Shirakavan samples. When compared to other samples examined by this study (Moldova, Ukraine /Chernyakhov culture/, Latvia) samples from Armenia is least similar. Given the small biological distances between the Ancient period samples from Armenia, the biological distances are most likely due to genetic drift and nonsignificant gene flow.

The biodistance results reported in this study indicate that differences among prehistoric mortuary samples from the Armenia are nonsignificant. Instead, based on nonsignificant biodistance results, it is suggested that an ancestral-

Table 9. Matrix of distance, values for fourteen Eurasia mortuary samples examined in this study.

Sample name	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1.Armenia /I period: Bronze Age/														
2. Armenia /II period: Bronze and Early Iron Ages/	2.38													
3. Shirak Plateau /I period/	0.57	2.71												
4. Artik	5.27	3.06	5.49											
5. Sevan region /II period/	1.71	0.72	2.04	3.59										
6. Akunk	6.26	3.92	6.48	1.71	4.59									
7. Lchashen	5.18	2.90	5.44	0.46	3.48	1.68								
8. Central Asia /Sapallitepe-Gonur Depe/	4.06	2.74	4.52	3.39	2.90	4.63	3.11							
9. Volga region /Fatianovo culture/	5.98	5.13	6.15	6.66	5.48	5.98	6.43	7.15						
10. Volga region /Balanovo culture/	5.29	4.62	5.57	6.55	4.92	6.16	6.26	6.28	1.59					
11. Siberia /Andronovo culture/	6.33	5.01	6.86	5.91	5.43	5.87	5.46	4.37	5.65	4.45				
12. Siberia /Afanasevo culture/	4.93	3.32	5.45	4.16	3.77	4.47	3.71	2.59	5.53	4.52	1.92			
13. Siberia /Karakolskaya culture/	3.87	2.35	4.38	3.94	2.76	4.36	3.54	2.49	4.88	3.88	2.68	1.14		
14. Siberia /Tagarskaya culture/	3.69	2.58	4.18	4.65	2.91	4.90	4.29	3.41	4.08	2.94	2.84	1.95	1.05	-

Table 10. Elements of three initial components for 10 groups.

Trait	I	II	III
Sutura metopica	-0.047	0.871	-0.143
Foramen supraorbitale	-0.802	0.497	-0.024
Foramen infraorbitale accessorium	0.397	0.859	0.159
Os asterii	0.659	-0.033	-0.456
Foramen parietale	0.826	0.006	0.012
Ossa suturae lambdoïdeae	0.658	0.630	0.061
Canalis condylaris intermedius	0.863	-0.343	0.266
Canalis hypoglossi bipartite	-0.074	0.042	0.916
Values	38.788	28.276	14.611

Table 11. Values of three initial components for 10 groups.

Sample name	I	II	III
Beniamin-Vardbakh-Black Fortress I	-1.275	2.011	-0.909
Karchakhpyur-Shirakavan	-3.518	-1.377	0.206
Armenia (IV period: Ancient Age)	-2.070	0.559	-0.162
Ukraine (Dzuravka)	0.154	-1.466	-0.555
Ukraine (Chernykhov-Romashki-Derevynnoe- Teleshovka)	1.641	0.606	-2.023
Ukraine (Gavrilovka-Voloshskoe)	1.302	-2.898	0.330
Ukraine (Koblevo-Ranjevoe-Viktorovka)	1.565	-0.052	0.625
Dnestr region (Budeshti)	-0.043	1.208	1.821
Dnestr region (Malaeshti)	1.484	1.310	1.105
Latvia (Latgali)	0.759	0.100	-0.438

Table 12. Matrix of distance, values for ten Eurasia mortuary samples examined in this study.

Sample name	1	2	3	4	5	6	7	8	9	10
1.Beniamin et al.										
2. Karchakhpyur-Shirakavan	4.21									
3.Armenia (total group: Ancient Age)	1.82	2.45								
4.Ukraine (Dzuravka)	3.78	3.75	3.03							
5. Ukraine (Chernykhov-Romashki-Derevynnoe- Teleshovka)	3.42	5.96	4.15	2.94						
6. Ukraine (Gavrilovka- Voloshskoe)	5.68	5.06	4.85	2.04	4.23					
7. Ukraine (Koblevo- Ranjevoe-Viktorovka)	3.83	5.27	3.77	2.32	2.73	2.87				
8. Dnestr region (Budeshti)	3.10	4.62	2.91	3.58	4.24	4.57	2.37			
9. Dnestr region (Malaeshti)	3.49	5.75	3.85	3.50	3.21	4.28	1.45	1.69		
10. Latvia (Latgali)	2.83	4.57	2.88	1.68	1.88	3.14	1.34	2.64	2.09	-

descendant relationship existed among Armenia populations from the Bronze Age through the Ancient period. While it is recognized (craniometric studies and dental traits) that significantly different immigrant populations in Ancient period may have been present in the prehistoric Armenia, they were not detected among the samples analyzed by this study (Khudaverdyan 2012a). These conclusions are consistent with those reported by other biodistance studies that examined nonmetric cranial and for Armenia samples. Further, based on the biodistance results presented here, we suggest that at the beginning of the Bronze period, there appears to have been a degree of genetic among inland populations. The biodistances reported here suggest that there was a decrease in isolation (*i.e.*, increased gene flow) among Ancient populations during 1st century BC – 3rd century AD. This assertion requires further exploration. In spite of this possibility, it is clear that the techniques employed in this study would have made it more likely to find significant differences among the samples, if any existed. In conclusion, biodistances from the nonmetric cranial traits reported here indicate that no significant prehistoric gene flow occurred in the Armenia.

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